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THE ARI SOUND CERTIFICATION PROGRAM FOR OUTDOOR UNITARY
EQUIPMENT AND COMPRESSORS

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INTRODUCTION

The necessity for locating houses and apartment buildings so close together, as in urban residential areas, presents the major problem, insofar as controlling the sound produced by outside air-conditioning equipment is concerned. In rural areas, houses are farther apart, and distance can be utilized to advantage, since, for example, the dBA level at the property line is reduced by 6 decibels every time the distance from the source of sound to the property line is doubled.

You may be asking why the ARI Sound Certification Program is included in a conference on Compressor Technology. Frankly, up to now compressor noise has not played a very important part.

LEGISLATION; PROPOSED AND ENACTED

However, a number of things are developing that will make the sound produced by compressors of greater importance in meeting sound regulations.

1. The dBA property-line values being proposed in legislation are being lowered.
2. In some instances proposed night-time values are lower than those proposed for daytime operation.
3. There are several jurisdictions proposing that substantially lower values, on the order of 5 dBA, are being called for now to become effective three years hence.
4. Noise is being packaged with air and water pollution at the federal, state, and local levels. As everyone knows reduction of pollution is fast becoming the order of the day. Interest in ecology, the environment and regulations against noise are here to stay. Like safety, I believe you will find them included in regulations everywhere--perhaps sooner than any of us even realize.

Currently, the compressor sound is obscured by the masking effect of the sound produced by the fan in an air-cooled condensing unit, which has become the typical application.

However, as lower sound levels are proposed in regulations, the sound of the fan must be reduced. However, in the magnitude of proposed sound reduction, it is fast being realized that when the fan sound is reduced to meet these requirements, the current sound level of compressors begins to come through.

This means that the new equipment designed to produce the lower sound levels will need to have a lower sound level from the compressors than is currently produced.

Because of the lead time entailed in revised design, the reduction of compressor sound level is both a vital and immediate consideration.

There are also indications that energy consumption may be included in legislative regulations. Reduced energy consumption and reduced sound could become important factors in efficient performance, as equal considerations along with safety in code ordinances and regulations.

Most of the states are already either looking at or considering proposals covering noise, and many of them have set up bodies to study and develop such regulations. In a number of cases such proposals have been made and a few already adopted.

RATING FOR SOUND

Under the ARI Sound Certification Program more than a thousand models already have been rated, which rating, together with the use of an application standard, will permit determination of what must be done by the installer to meet proposed regulations, how to go about doing it, or whether regulations under consideration can be met at all. In this respect, the air-conditioning and refrigeration industry is unique in already having such a program in being. It has taken a dozen years to set it up, since, the ASHRAE Testing Standard was started as a first step.

The sound values are listed in a directory which also includes the thermal capacity of unitary air-conditioning units and heat pumps up to 135,000 BTU capacity. By incorporating sound into this directory, advantage was taken of the existing

mailing list, which is substantial among the engineers and contractors who design and install such systems. The directory is printed three times a year with 28,000 at each printing. Distribution is free and generally available within the industry.

While sound numbers were included for the first time in January, 1971, the directory itself has been published and distributed for about a dozen years.

The ARI rating numbers are set to provide penalties for whines, screeches, rattles, and other irritating types of noise, and if these sounds are not removed from specific models, their rating numbers can be raised by one or two digits. Generally, the outdoor condensing unit for residences is rated in the range of 18, 19, 20, or 21. There can be a lower number on smaller size units and a higher number on larger units. These are ARI numbers and, when the units are installed in accordance with the application standards, result in the dBA values at a given point, such as the property line, a patio or outside a living area window.

GOVERNMENT COOPERATION

A packet of material for the use of political jurisdictions for guidance in establishing regulations, and recommended technical requirements of an ordinance to regulate sound produced by air-conditioning and air-handling equipment, are available to political jurisdictions upon request.

Both a motion-picture film, "Quest for Quiet," and a training packet with slides is available for loan by contacting the Public Relations Department of ARI. This material is being regularly used by local and regional chapters of various associations such as ASHRAE, Refrigeration Service Engineers Society, and the National Environmental Systems Contractors Association. It could be used just as effectively in classrooms, and could similarly be loaned for this purpose. Instructor guidance is also available for use with the material.

To give you some idea of what it is and how to use it, I would like to run through a number of illustrative figures, and several typical application problems. These will illustrate that the sound of the equipment itself is only half of the problem, the other half is how and where the equipment is installed. Installing the best unit in the world directly under a neighbor's open window would create a problem, so that application and location must be understood, and are of primary importance.

Figure I (see appendix for Figures I through VIII) illustrates how residential installations started. They were water-cooled, and frequently the waste water was used to water the lawn. The first room air-conditioners also were water-cooled. Obviously they made no outdoor sound since all of the equipment was indoors. However, the problem of a shortage of water resulted in outlawing, as a general thing, all waste water installations.

The purpose of showing this calculation is to establish the fact that when you want an air-cooled condensing unit you need something like 700 cfm of air per ton to dissipate the heat. This is arrived at by use of the following abbreviated formula:

$$\frac{250 \text{ btu} \times 56}{20^\circ} = 700 \text{ cfm}$$

While a ton of refrigeration amounts to 200 btu per minute on the cooling side, it is generally taken as 250 btu on the condenser side to include the heat of the motor. The factor of 56 is derived from the weight and specific heat of a cubic foot per minute of standard air. A typical condensing temperature of 125° with 95° entering air and a 10° spread, establishes the 20° rise shown in the formula to give 700 cfm per ton. Obviously, this kind of air quantity cannot be moved without an audible operating sound.

So much for a backward view on how and why we got to where we are today in central residential air-conditioning installations. Originally even small and medium sized commercial installations used waste water condensers so the same situation applies to commercial applications.

Urban residential areas where the houses and apartments are close together represent the basic problem, as I have pointed out. Even here the background sound level varies from day to day and hour to hour, and day to night, even in different parts of the same city, so ARI went to an indoor level as the starting base for acceptability since it is independent of outdoor sounds. A 40 dBA criterion was selected as the upper limit of acceptability from the ASHRAE Guide and Data Book and the Harris Handbook of Noise Control for the room sound level in an urban environment. We are talking about the sound level in a typical furnished bedroom with an open window 15 feet from, and facing the property line. It was originally proposed that sound pressure levels 5 db in excess of the 40 dBA as measured at the point of complaint in the bedroom on a sound level meter, be the limit before any remedial action be required. As shown in Figure II, through accepted acoustical procedures, an equivalent sound level of 56 dBA, with the equipment on, at 15 feet distance from the line, was calculated at the property line for one of 40 dBA or NC-35 in a typical bedroom by using the formula shown. Since most people have difficulty discriminating between similar sounds differing by less than 3 db, a 4 dBA tolerance above the design goal was suggested before a basis for legal action could be determined, which would represent the 60 dBA illustrated as an example in the Recommended Technical Requirements, for this specific situation, furnished jurisdictions.

The ARI Standard for Sound Rating of Outdoor Unitary Equipment was developed in 1967. In this standard, the rating of equipment, as obtained at specific Standard Operating Conditions, is in the form of single numbers, designated as ARI Standard Sound Rating Numbers, which are tabulated in the

ARI Directory of Certified Sound-Rated Unitary Equipment. The latest issue may be obtained by writing to ARI.

Let's compare what these rating numbers require in the way of distance to the property line in order to achieve the 56 dBA at the line with 40 dBA in the room. Figure III indicates how you can use units with different rating numbers and still get 56 dBA at the property line by placing the unit farther away. It can also be used to show how you can get a value of less than 56 at the line. You might ask how the values can be reduced if we do not have enough property width to back the unit up any appreciable distance, which will be explained.

I would like to discuss how to use the application factors that must be taken into account for a typical single unit installation on the ground like the average residential application. For multiple units and more involved applications it is necessary to refer further to ARI Standard 275.

But first let me repeat. The ARI rating system has a built-in penalty for whistles, whines, screeches, and other people-irritating sounds--types of noise you do not pick up on any meter. If the manufacturer does not eliminate them, his equipment may end up with a rating that is one or two numbers higher.

CALCULATION METHOD

Here is how to calculate dBA at a given point such as the property line. After first looking up the rating number in the rating Directory, you look up the equipment location factor (1. in Figure IV) which Figure is duplicated in its entirety in the instructions on the cover of the pad of nomogram calculation sheets, and in the application standard. Pads of twenty-five of these sheets are purchasable from ARI for use in calculating individual installations and each pad has complete directions on the cover. If there will be no reflective surfaces within ten feet of the unit, as shown in drawing 1. a., there is a factor value of zero. In drawing 1. b. the factor value is one.

Drawings 1. c. and 1. d. present two situations where there are two reflective surfaces and the factor value is two. All of these are a part of the instructions on how to calculate the dBA value of any contemplated installations so that for the first time it is possible to predict and control the sound level before an installation is actually made. Until this method was developed, it was necessary to make the installation first, and then check sound level with a meter.

Figure IV, 2. shows how to assign a "barrier shielding factor", such as a separate wall or even the corner of a building between the unit and the point of evaluation.

Then (Figure IV, 3.) instructions are given on the assignment of a sound path factor. If the point of evaluation is outdoors, such as the property line, this factor is zero. The final preparatory step is the determination of the distance from

the unit to the point of evaluation.

Then you are ready to work out the formula. You take the rating number--add the equipment location factor, -- subtract the barrier shielding factor and the sound path factor. The result is the sound level number.

Here is how it works, and really it is quite simple as illustrated below. Take a point on the property line nearest the unit--assume the rating number is 19--and there is only one reflective surface so the location factor is 1. There is no barrier shielding factor and the sound path factor is also zero, so the sound level number is 20 and the distance from the unit to the point of evaluation is given as 40 feet.

Now use what is called a nomogram, (see an example in Figure V) which is printed in the Standard and also on the calculation forms in the pad, to predict the sound level at the point desired. A line drawn on the nomogram from a Sound Level Number of 20 on the left to the distance of 40 on the right shows that the sound level on the property line will be 53 dBA.

Here is a more complex example (Figure V) using a barrier wall. It may be used as a solution to a problem, particularly in a very quiet area where the residents desire such a zoning and are willing to pay the added cost of a wall to get it. It can also be used as an illustration to legislators where their constituents are unwilling to pay a higher cost. The point of evaluation is again the nearest point to the unit on the property line. In this case assume the unit's rating number is 21. The equipment location factor is one--the barrier factor is as follows: L-one is $9\frac{1}{2}$, L-two is $19\frac{1}{2}$, which totals 29--from which we subtract D which is 28, leaving L as 1. Then our index tells us that when L is 1, the barrier shielding factor value is 2. Note the wall is heavy, such as eight inch cement block and it needs to be at least twice as wide as it is high in order to prevent sound going around the ends. The sound path factor is zero, because the point of evaluation is outdoors. Adding 21 and the equipment location factor of 1, and subtracting the shielding factor of 2, we come up with a sound level number of 20. The distance is given as 28 feet. It is simple to use the nomogram and determine that the sound level at the property line will be 56 dBA.

Figure VI illustrates the barrier effect in reducing both the SLN and the distances shown in Figure III.

During the past year a fair number of this type of presentation has been made to contractor groups and local chapters of ASHRAE, RSES and NESCA and more will follow. In each of these we have the audience participate in some problems.

Figure VII is from the answer page to one of the problems and it illustrates that every time the distance is doubled, the dBA value at the point of evaluation is reduced by 6. With a unit sound rating number of 19 and an equipment location factor

of 1, we get the Sound Level Number of 20, which at a distance of 10 feet provides 65 dBA at the property line. In the second illustration, with the same unit at a distance of 20 feet, we get a dBA value at the property line of 59, or 6 less. And again, for the same unit, with a distance of 40 feet the dBA becomes 53, or 6 less again.

This next answer, in Figure VIII, is particularly interesting because we have just raised the question as to what is the best location for a unit from a sound standpoint. In position 1, in front of the house; position 2, in back of the house, or 3, at either side of the house—as affecting four surrounding buildings—one on each side, one in the rear, and one across the street. The two on the sides are shown as the same distance from the property line and the air-conditioned house is shown as centrally located on its lot from both sides.

The answer is--the location of the unit in the front is best; in the rear is second best; and on the side is the worst of the three. Locating the unit in the front may shock you a bit, but let's consider the advantages. First, it is as good as any location for the two neighbors on each side as far as the property line's closest point is concerned, and bedroom windows on the side of the adjacent houses should get some barrier factor from the corner of the air-conditioned house, which would lower the sound level coming into an open window. Second, nobody ever has his own patio or swimming pool in the front yard. It is always in the back, so in areas where people like to spend a lot of time outdoors, even though their own houses may be air-conditioned, this is obviously the very best location from a sound standpoint. And third, of course, the house itself is a shielding factor for the house in the rear and for the house across the street you get the added distance of the width of the street itself.

Recently there was an article in the trade press showing a picture in which such an installation had been made and the owner had decorated it with a miniature statue of an astronaut climbing a ladder to about half the height of the unit, which was distinctive, attractive, and, according to the article, provided a lot of attention. With an up-discharge unit it might also be concealed by shrubbery. There seems to be a growing acceptance of this as a desired location. Some houses are also built with the living rooms and bedrooms in the back with the kitchen, bath, garage and other service areas in front so the concept can present a worth-while design challenge particularly if used in an entire housing project.

CONCLUSION

The foregoing brings out the fact that the designer of compressors and the designer of the units into which they are incorporated must be educated to and have in mind prescribed regulations covering sound as well as safety and energy consumption. The background information offered here today may help to provide an insight into the importance compressor sound level will play in the near future.

It may involve such items as the internal muffler design, the use of some measure of capacity control or multiple compressors, the design of the compressor itself, the reduction of noise on start-up, a compressor enclosure within the casing and so forth.

Most noise complaints occur at night when the load is reduced, thereby increasing the frequency of compressor cycling. The start-up noise is usually greater than the operating noise and therefore contributes to complaints. A person may become accustomed to a steady sound but at the same time find an on-and-off sound even at the same sound level objectionable and usually the start-up sound has been greater. Selecting a reduced capacity will take advantage of the fly-wheel effect of the building to reduce night-time cycling. Many factors contribute to maintaining full or increased capacity with lower night-time outdoor temperatures to build storage into the building. It should be kept in mind that a smaller size plant, by taking advantage of storage, can also have a favorable effect on the energy requirement by reducing both the connected horsepower and power consumption. Since most indoor fan systems operate continuously, there is a further advantage with reduced cycling since there is less tendency to re-evaporate water that was removed from the air. With the compressor on the off cycle and the indoor fan running continuously, the wet coil becomes a humidifier as its temperature rises. This results in a higher average relative humidity in the conditioned space which minimizes one of the health and comfort benefits of air-conditioning. There is one further point, the less tendency there is for noise complaints, the less likelihood that highly restrictive legislation will be proposed in the first place.

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Appendix Follows.

APPENDIX--FIGURES I THROUGH VIII

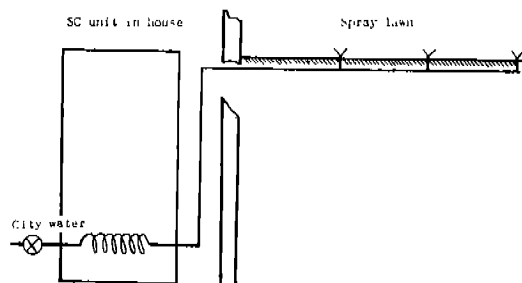


FIGURE I

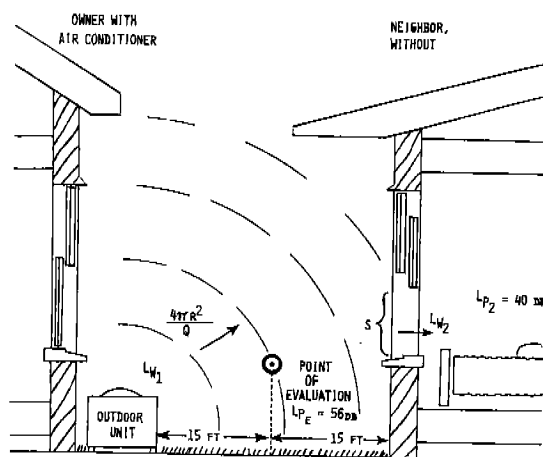


FIGURE II

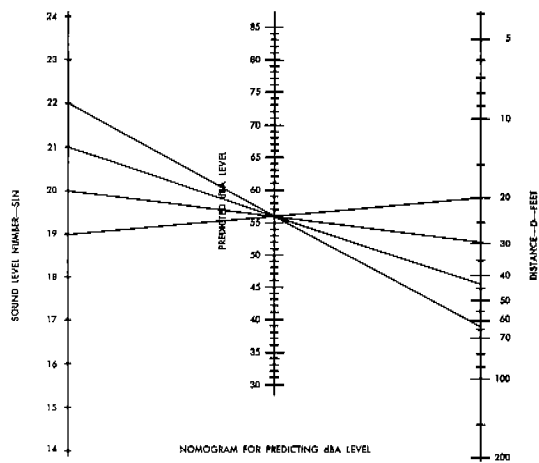
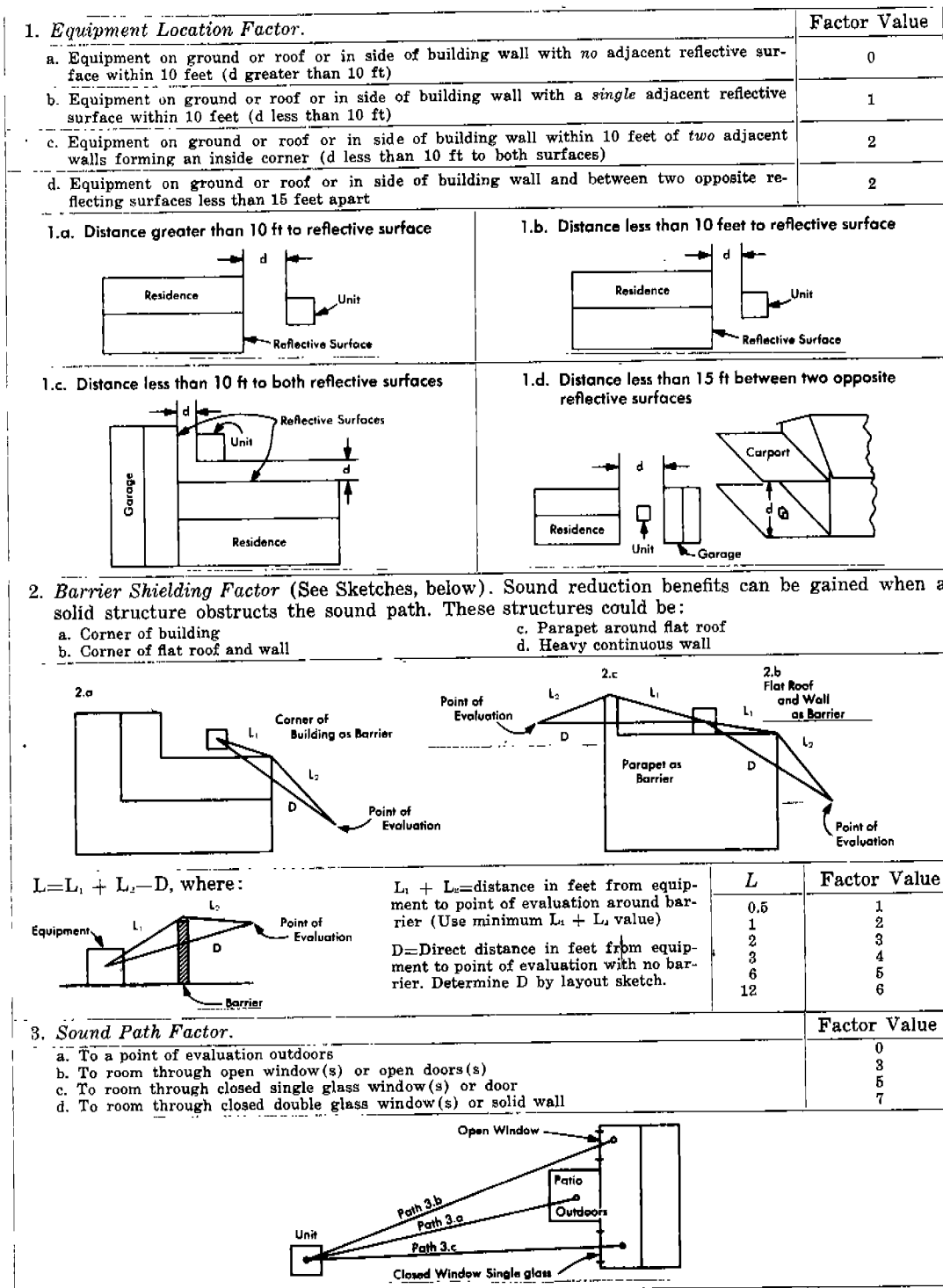


FIGURE III

FIGURE IV



A SUGGESTED SAMPLE TO GROUP THE LOCATION FACTOR DIAGRAM AND SLM CALCULATION TOGETHER WITH THE MONOGRAM AND DESCRIBE THE INSTRUCTIONS TO OBTAIN THE DBA RATING AT THE POINT OF EVALUATION

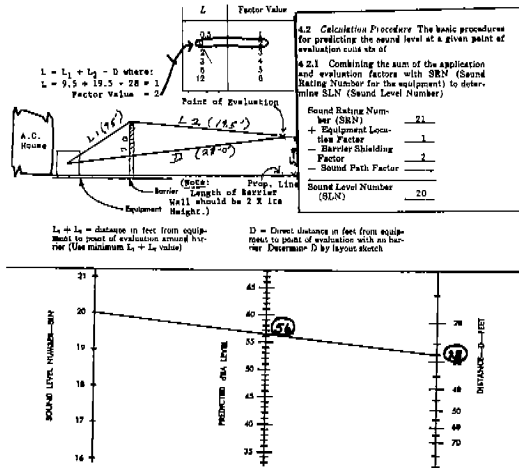


FIGURE V

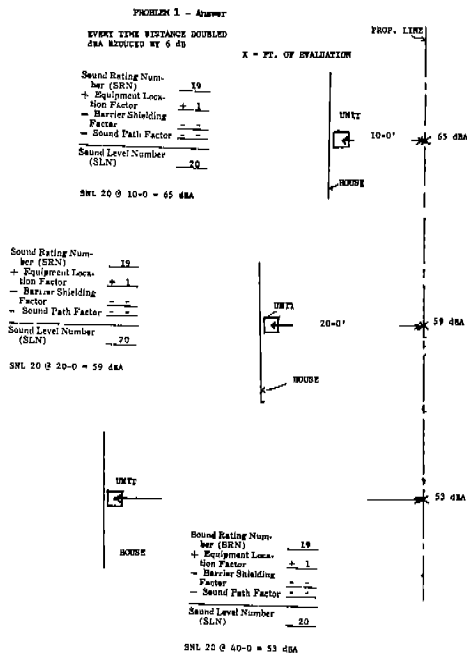


FIGURE VII

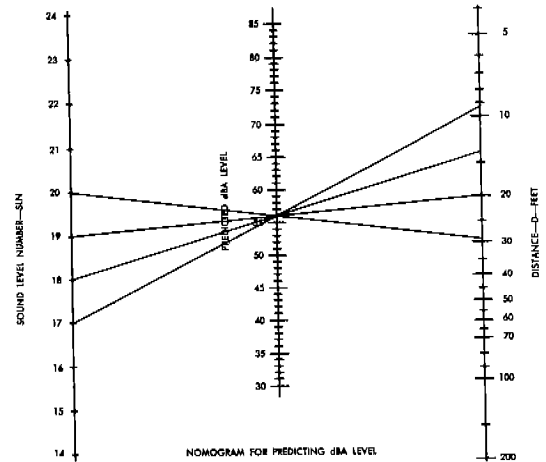


FIGURE VI

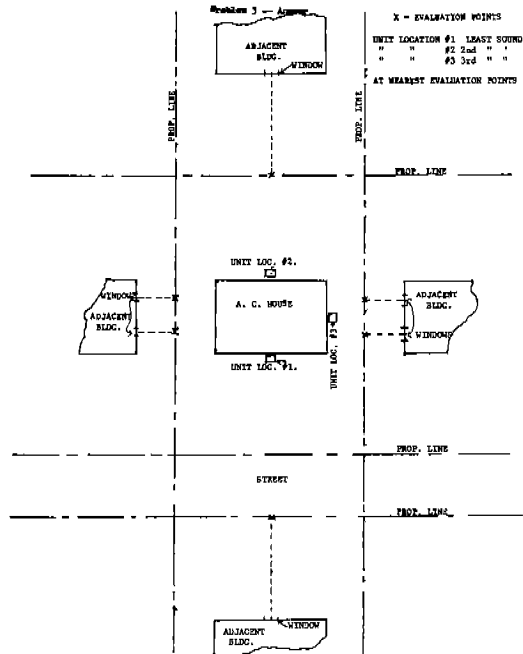


FIGURE VIII